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McKibben et al.

(10) Patent No.: **US 9,482,041 B2**
(45) Date of Patent: ***Nov. 1, 2016**

(54) **DOOR ACTUATOR**

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(73) Assignee: **Schlage Lock Company LLC**, Indianapolis, IN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 122 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/445,714**

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(65) **Prior Publication Data**

US 2015/0020350 A1 Jan. 22, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/243,657, filed on Sep. 23, 2011, now Pat. No. 8,793,838.

(60) Provisional application No. 61/445,419, filed on Feb. 22, 2011.

(51) **Int. Cl.**
E05F 3/00 (2006.01)
E05F 3/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***E05F 1/1246*** (2013.01); ***E05F 1/10*** (2013.01); ***E05F 1/105*** (2013.01); ***E05F 3/00*** (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC E05F 1/1246; E05F 1/10; E05F 1/105; E05F 3/00; E05F 3/227
USPC 16/71, 79, 80, 72, 59, 60; 49/339, 340, 49/341, 344, 346, 386; 292/137, 163, 169, 292/175
See application file for complete search history.

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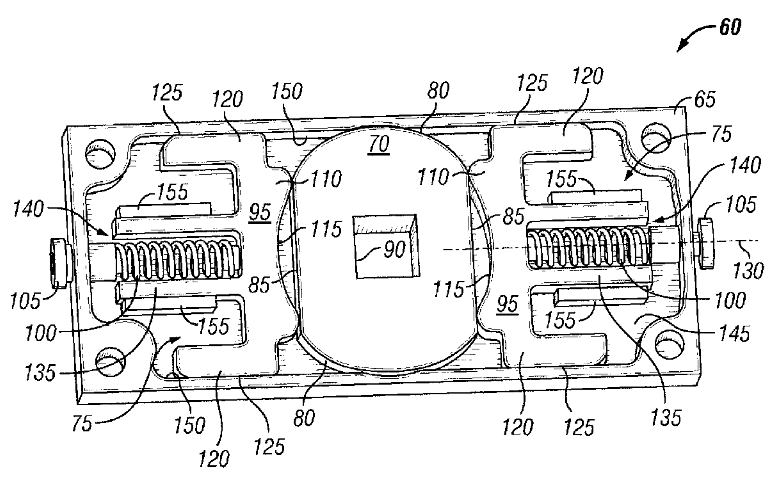
(57) **ABSTRACT**

A power boost assembly is disclosed that can be used with a door actuator, such as a door closer. The power boost assembly is structured to store an energy during a first movement of a door and release the stored energy during a second movement of the door. In one form the power boost assembly can be structured as a module that can be added to an existing door and door closer installation. In one form the power boost assembly is used to increase a closing force imparted to a door to ensure a latching event.

20 Claims, 16 Drawing Sheets



(51) **Int. Cl.**

E05F 1/12	(2006.01)
E05F 1/10	(2006.01)
E05F 3/22	(2006.01)

(52) **U.S. Cl.**

CPC ***E05F 3/227*** (2013.01); *E05F 3/104* (2013.01); *E05Y 2201/412* (2013.01); *E05Y 2201/42* (2013.01); *E05Y 2201/638* (2013.01); *E05Y 2800/205* (2013.01); *E05Y 2800/70* (2013.01); *E05Y 2800/72* (2013.01); *E05Y 2900/132* (2013.01); *Y10T 16/27* (2015.01); *Y10T 16/293* (2015.01); *Y10T 16/56* (2015.01); *Y10T 16/593* (2015.01); *Y10T 29/49716* (2015.01)

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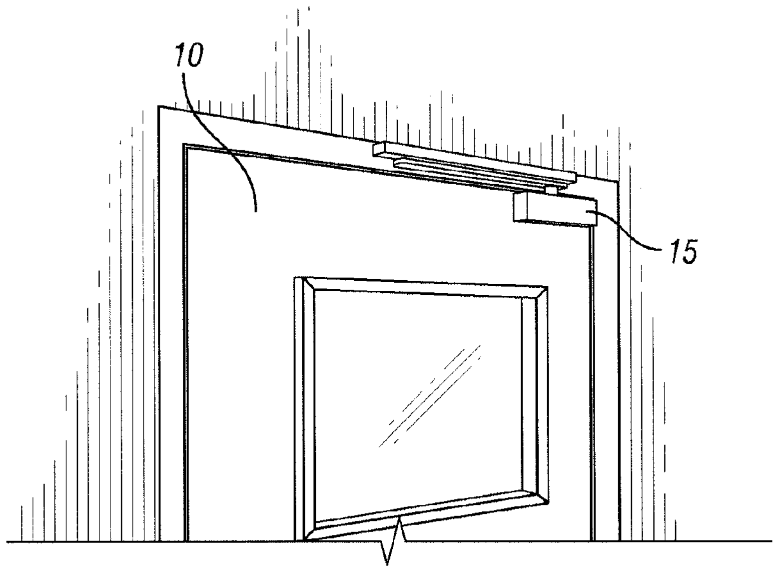


FIG. 1

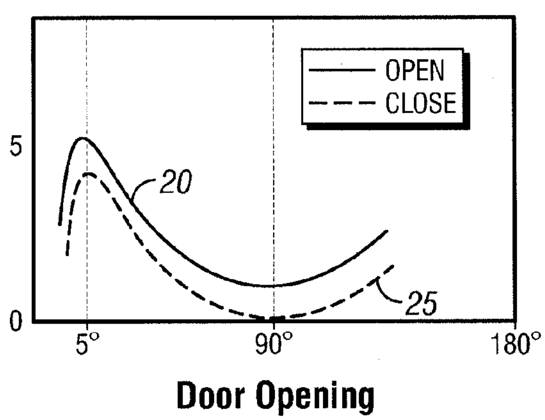


FIG. 2

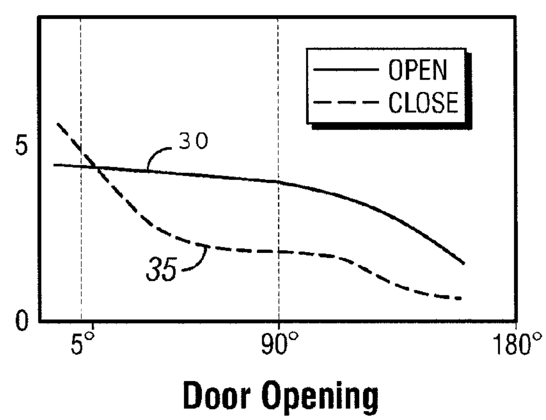
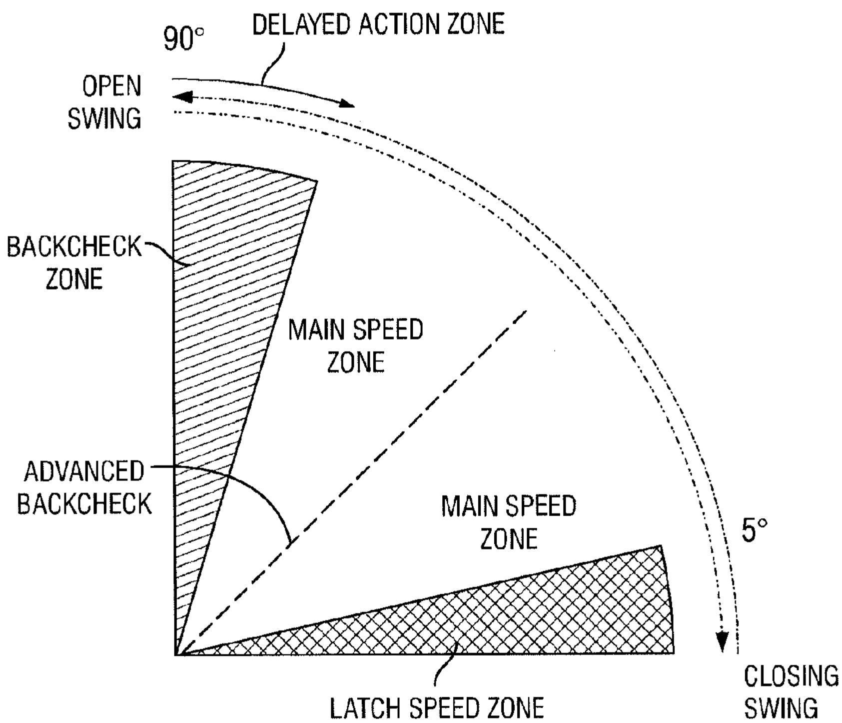


FIG. 3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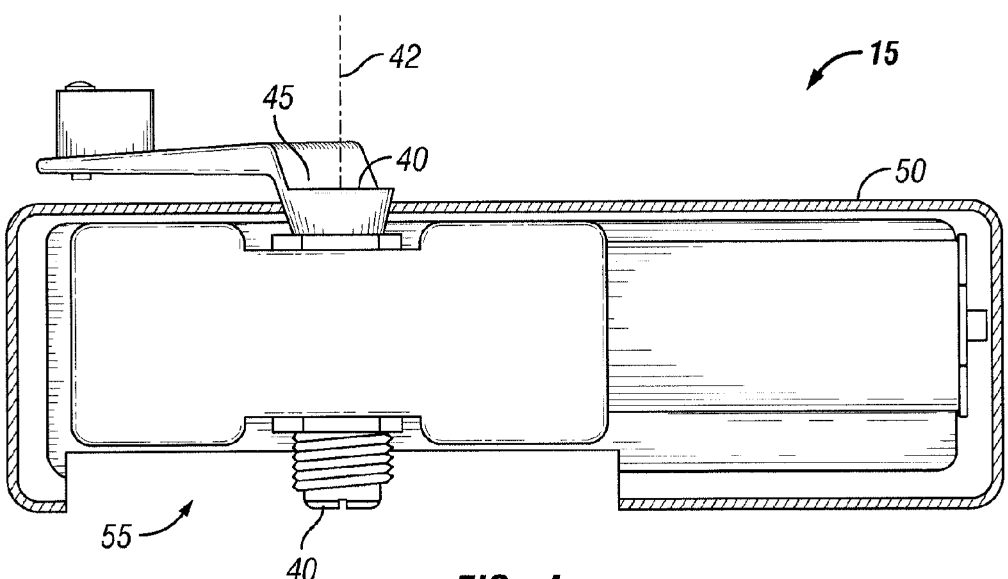
BACKCHECK
ZONE
MAIN SPEED
ZONE
ADVANCED
BACKCHECK
MAIN SPEED
ZONE
5°
LATCH SPEED ZONE
CLOSING
SWING

FIG. 2A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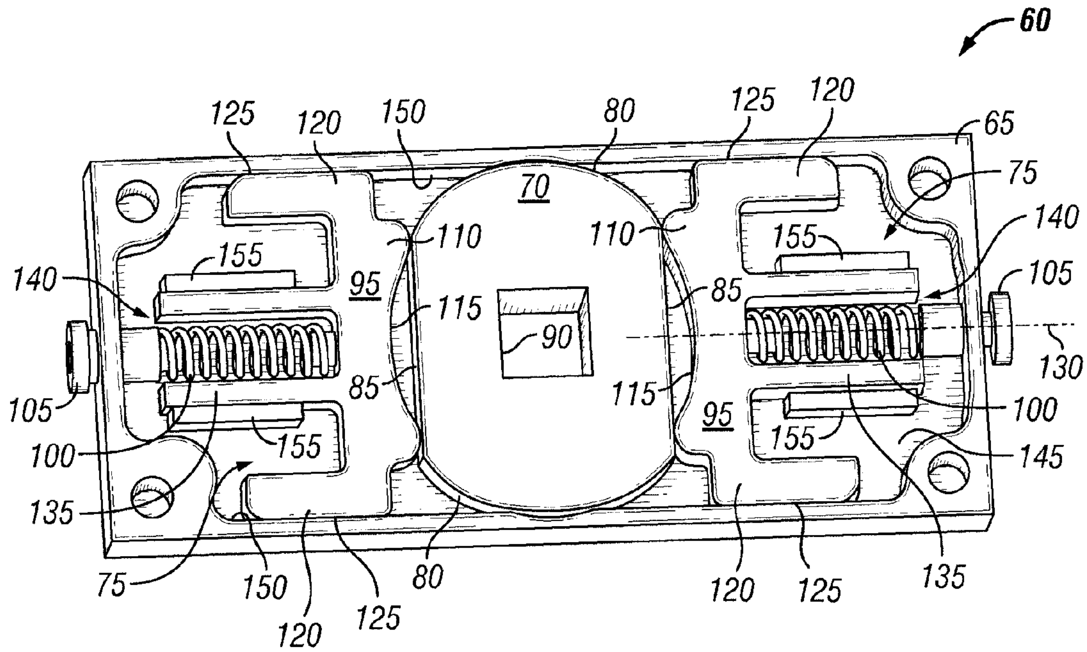
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FIG. 5

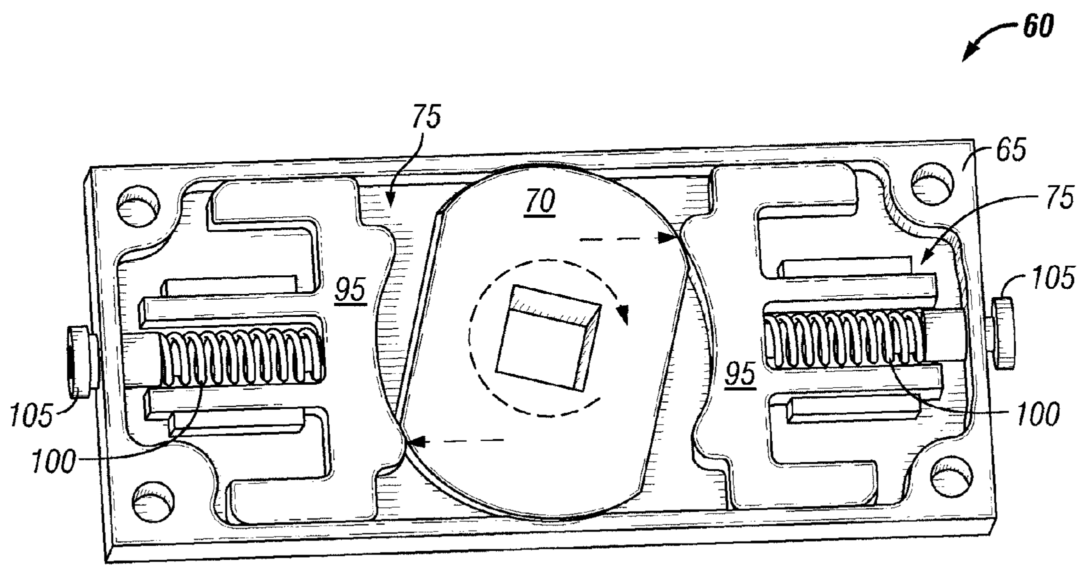
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FIG. 6

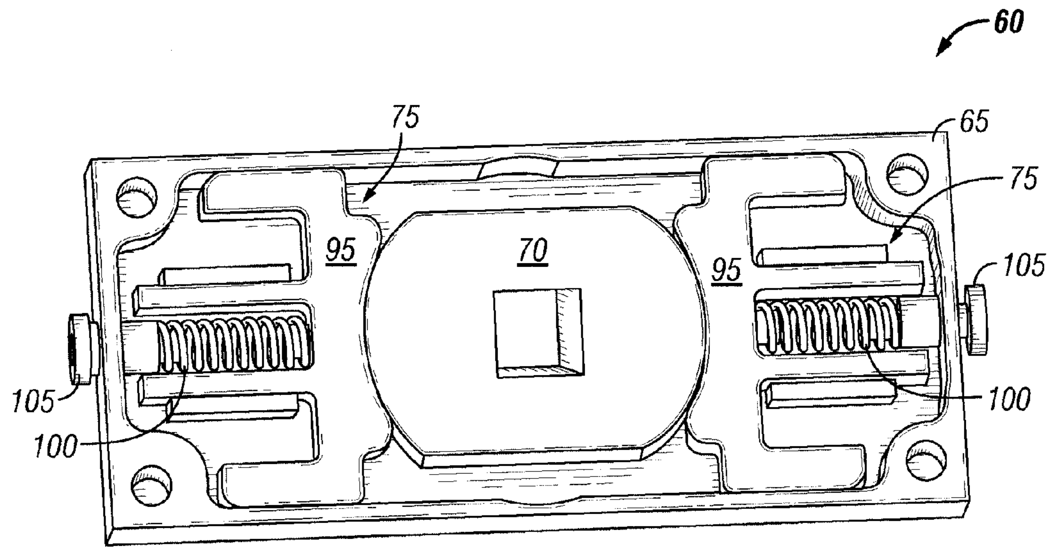
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FIG. 7

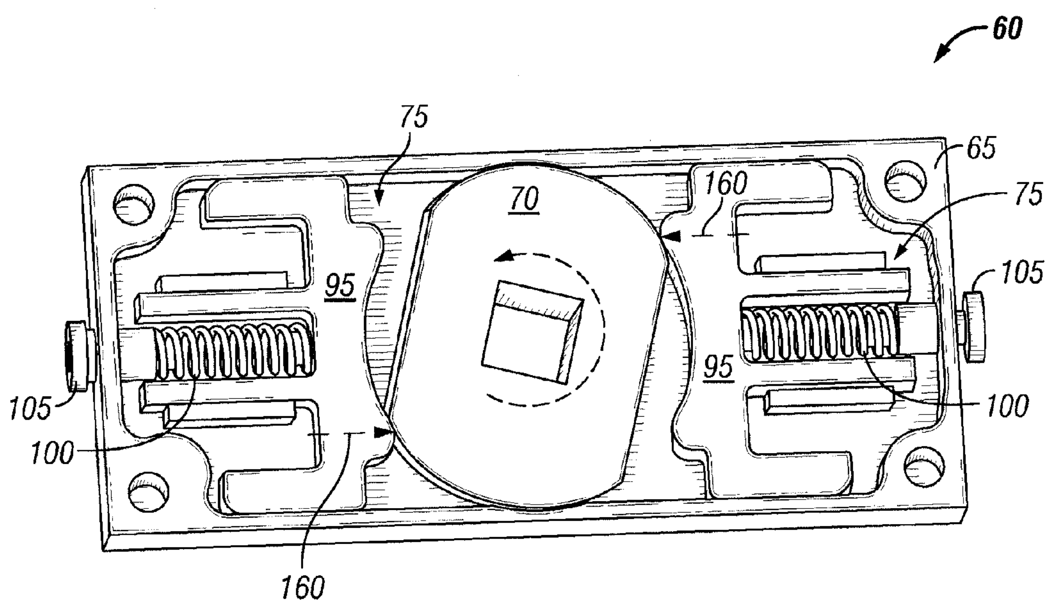
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FIG. 8

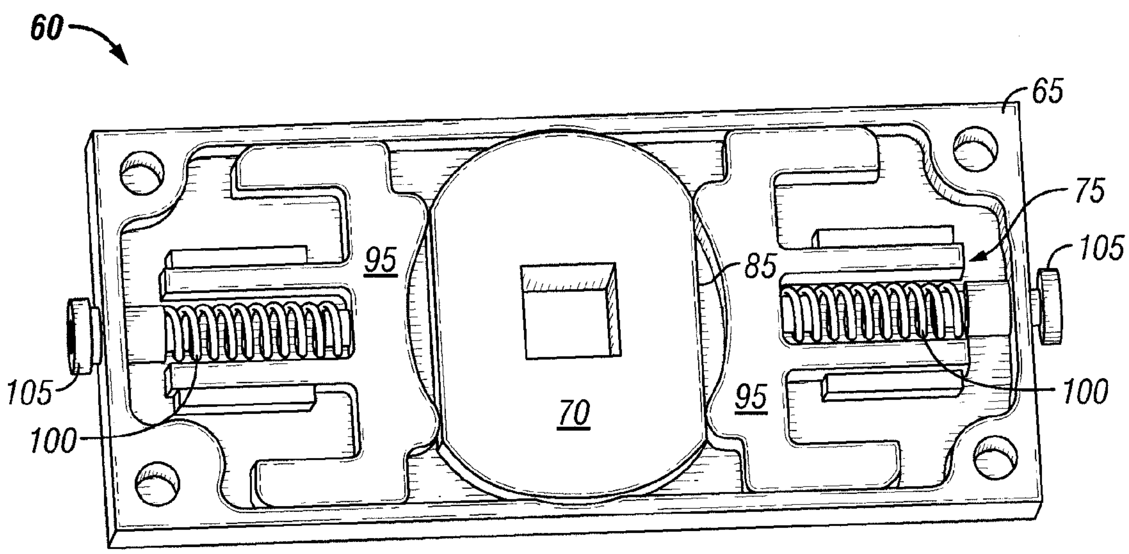
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FIG. 9

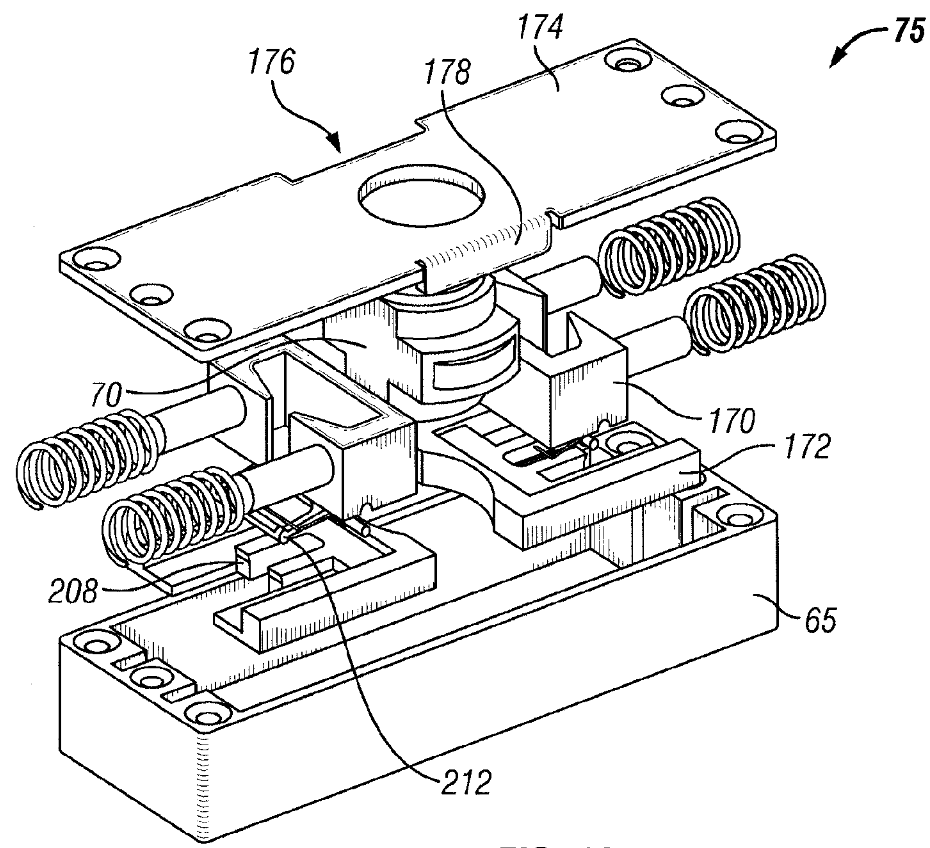
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FIG. 10

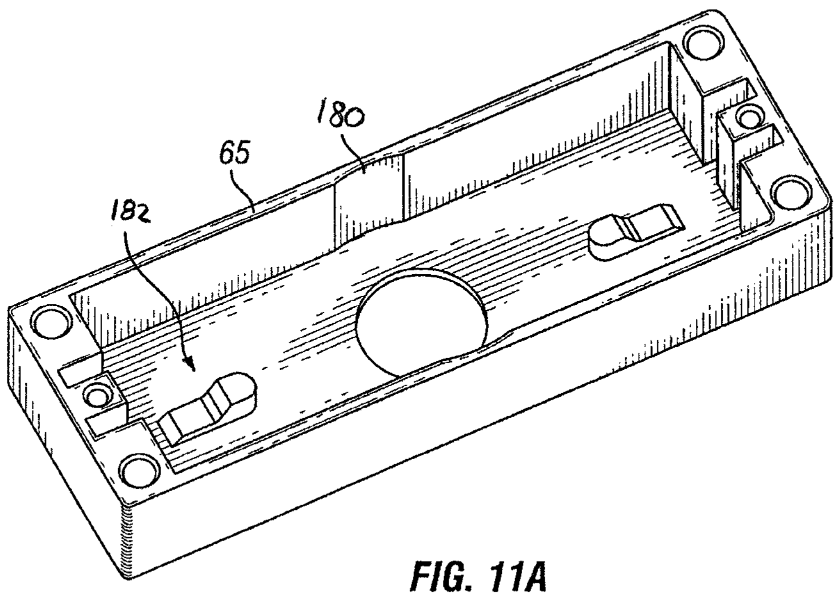


FIG. 11A

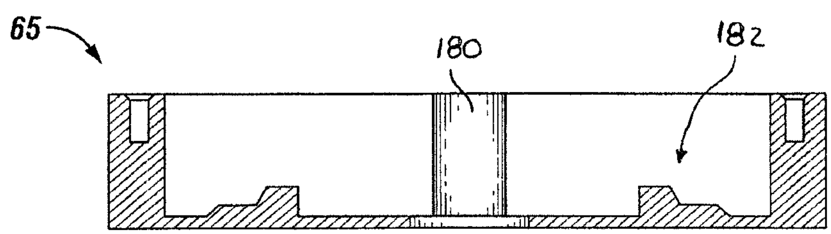


FIG. 11B

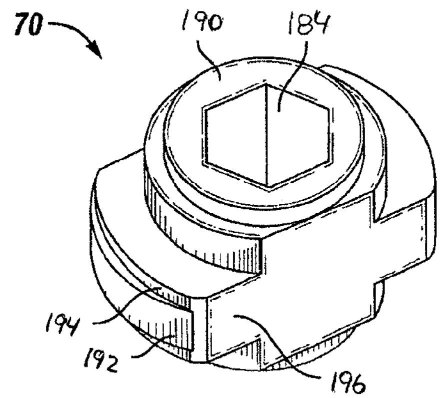


FIG. 12A

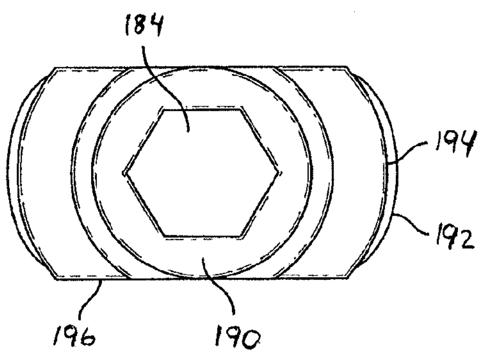


FIG. 12B

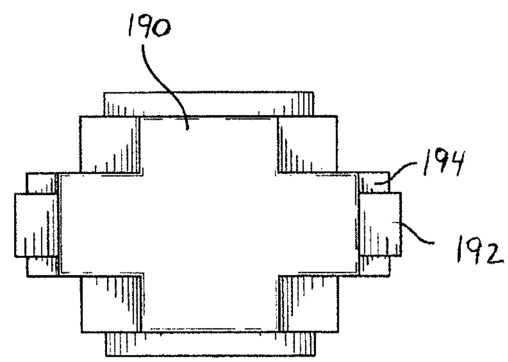


FIG. 12C

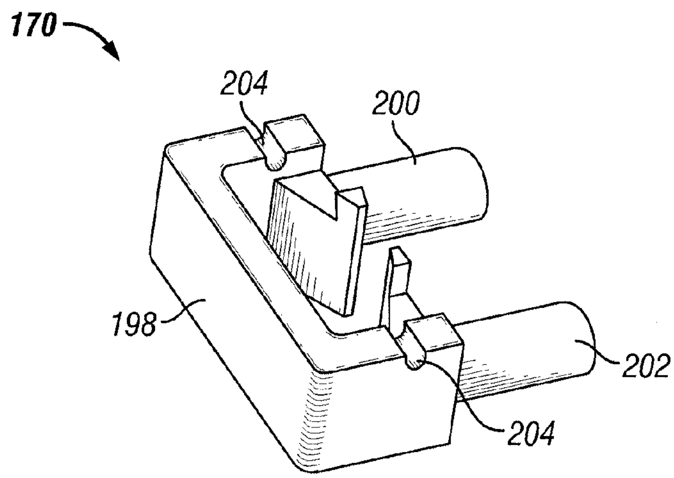


FIG. 13A

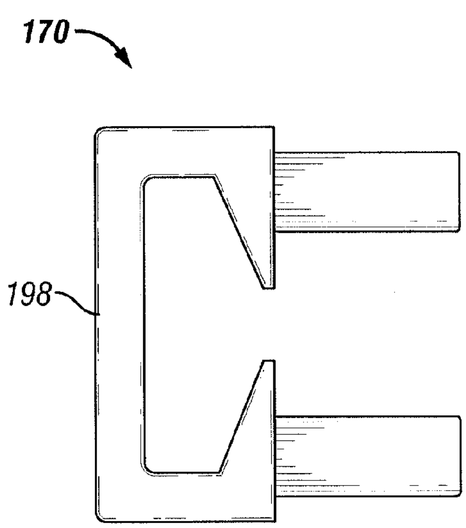


FIG. 13B

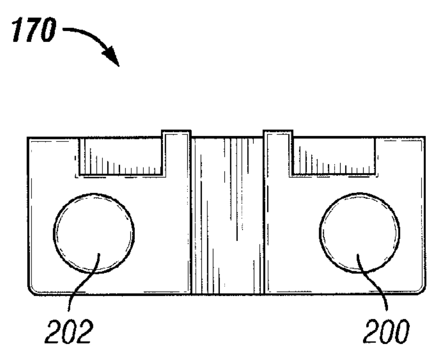


FIG. 13C

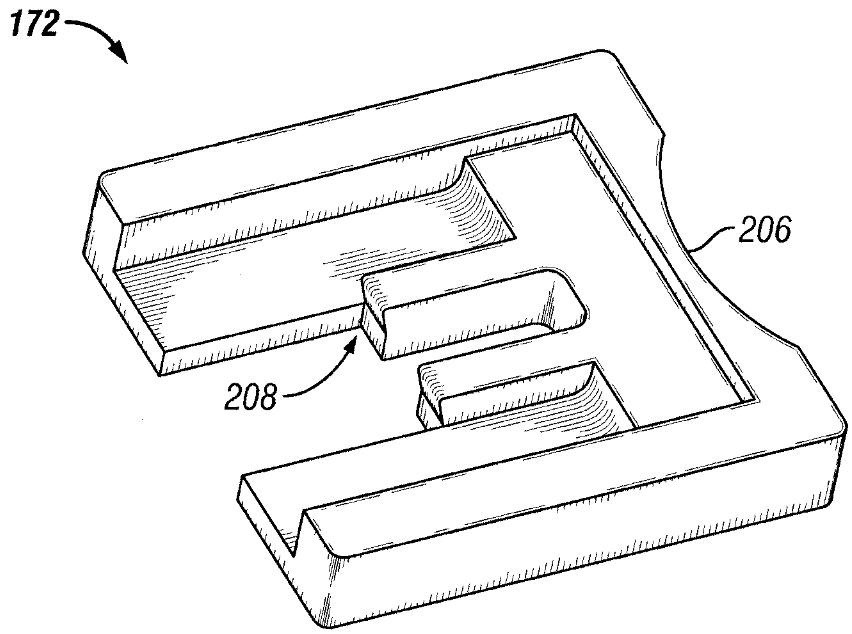
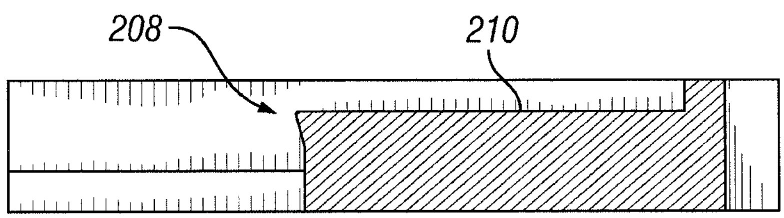


FIG. 14A



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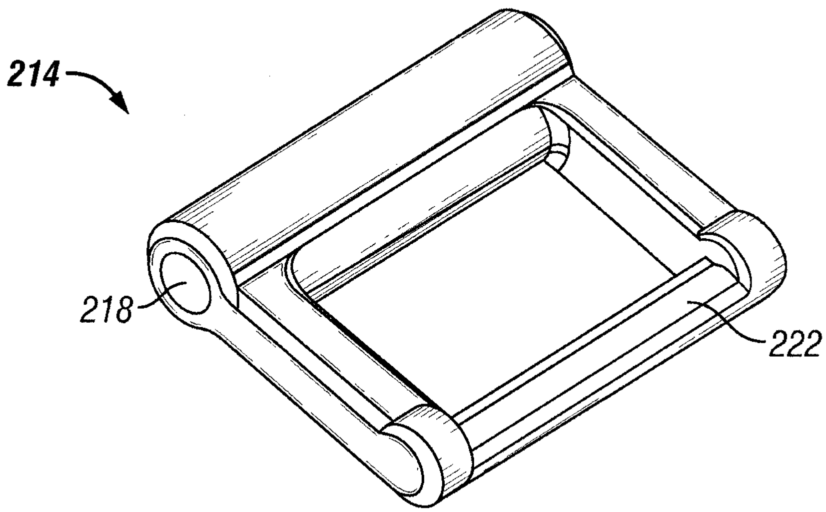

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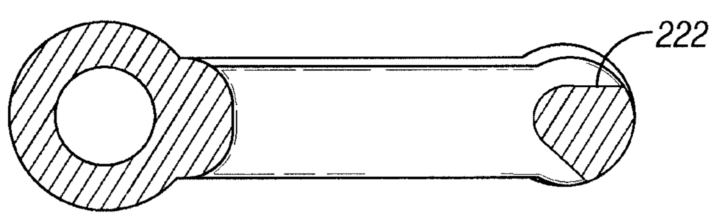

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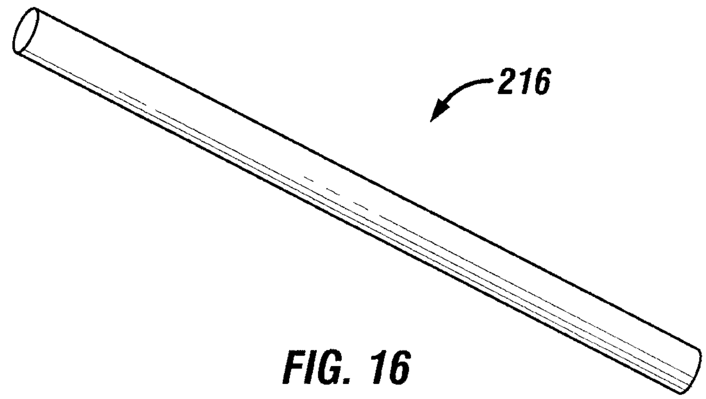

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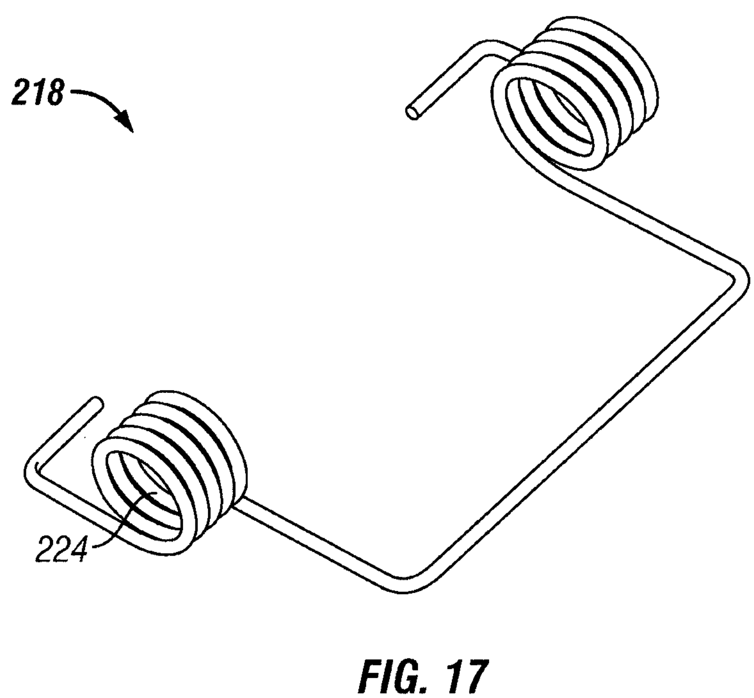

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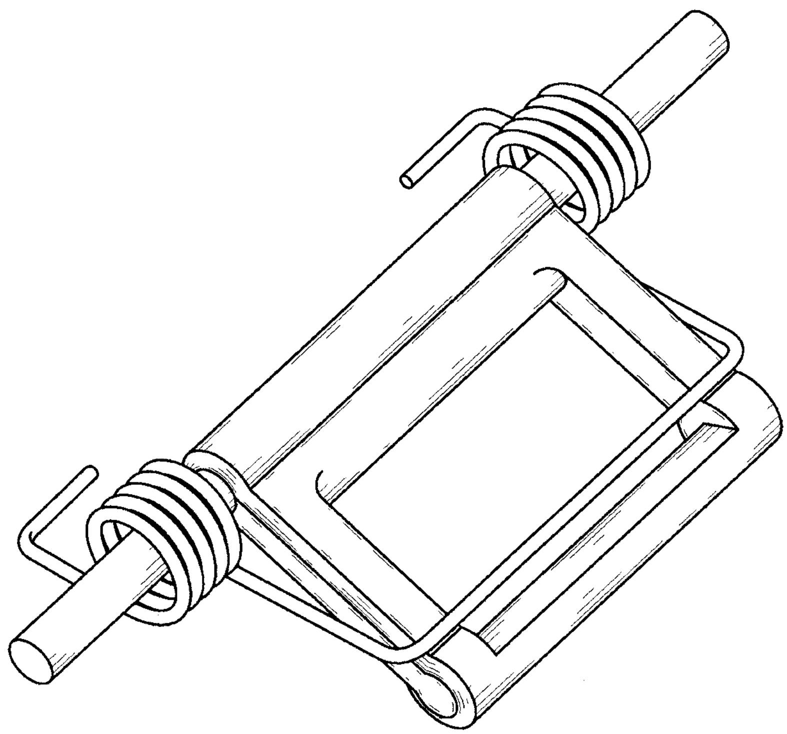

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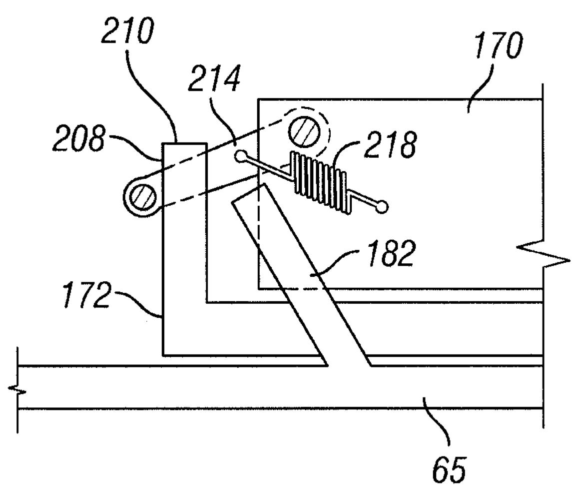

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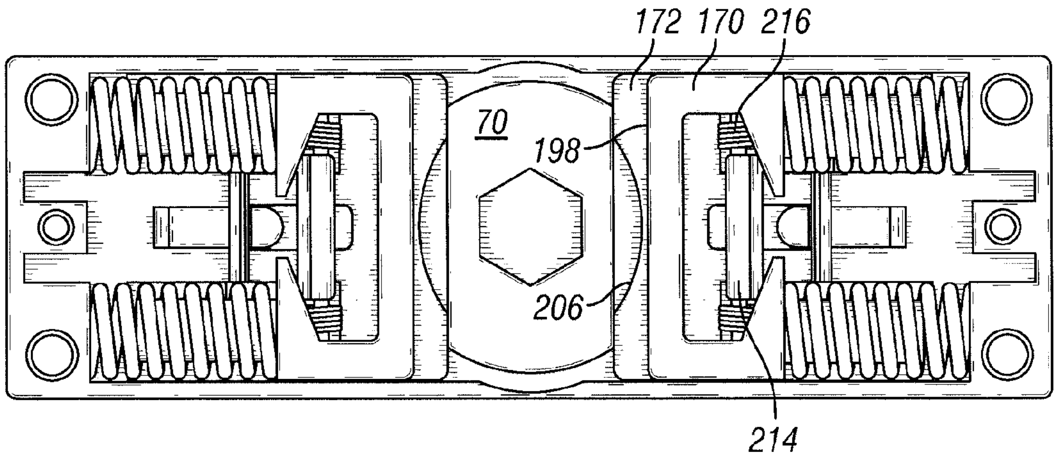

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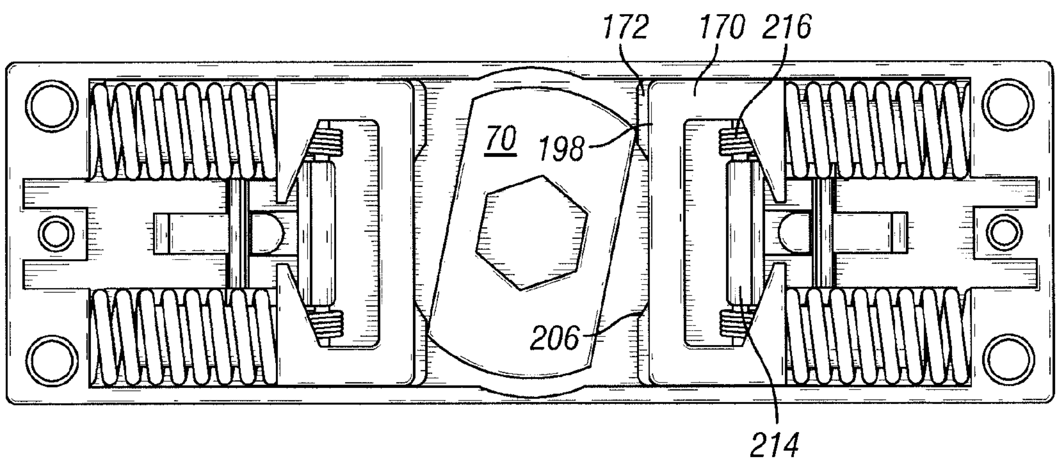

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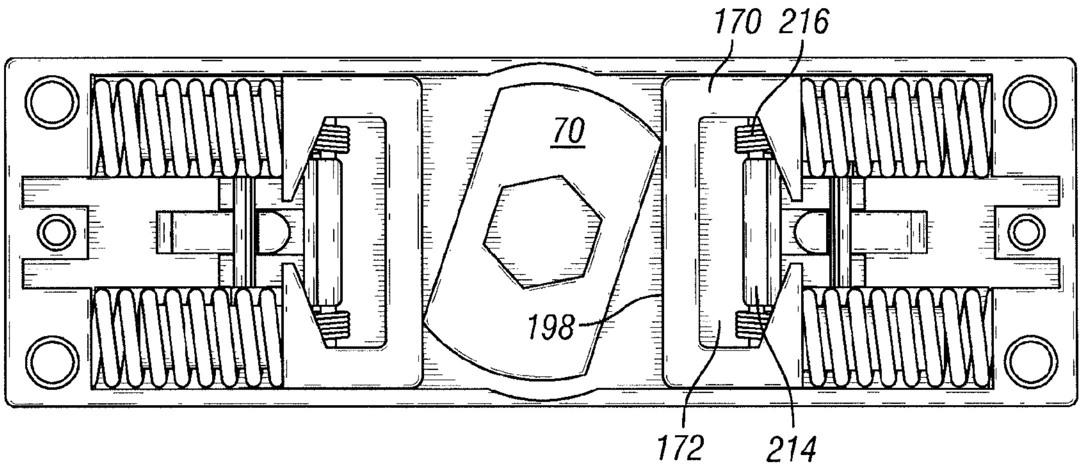

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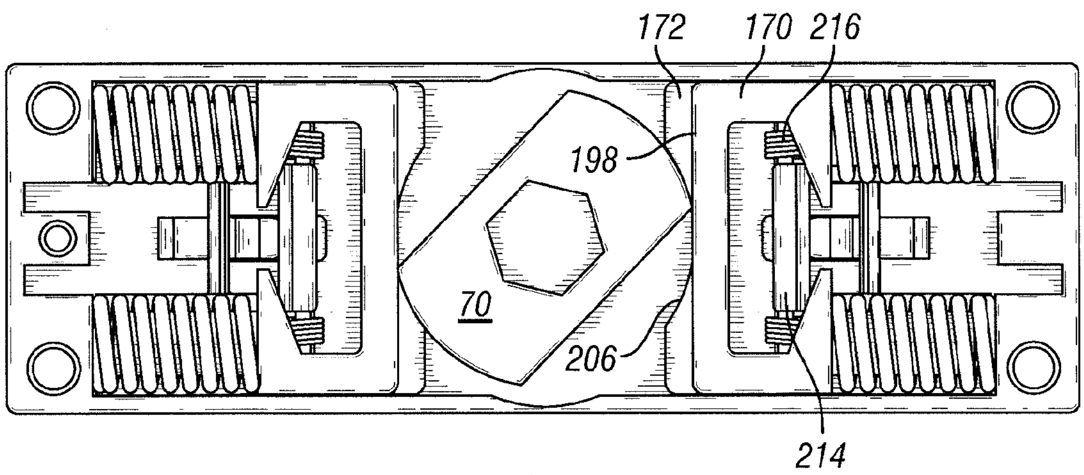

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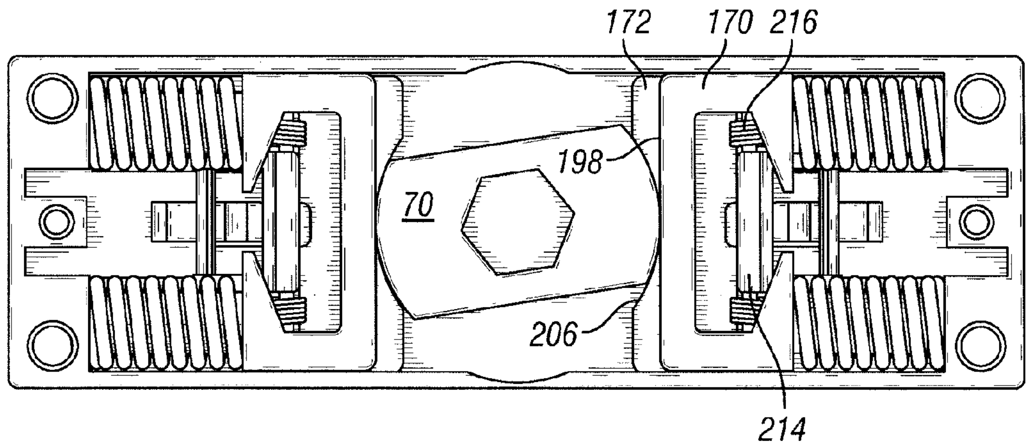

FIG. 24

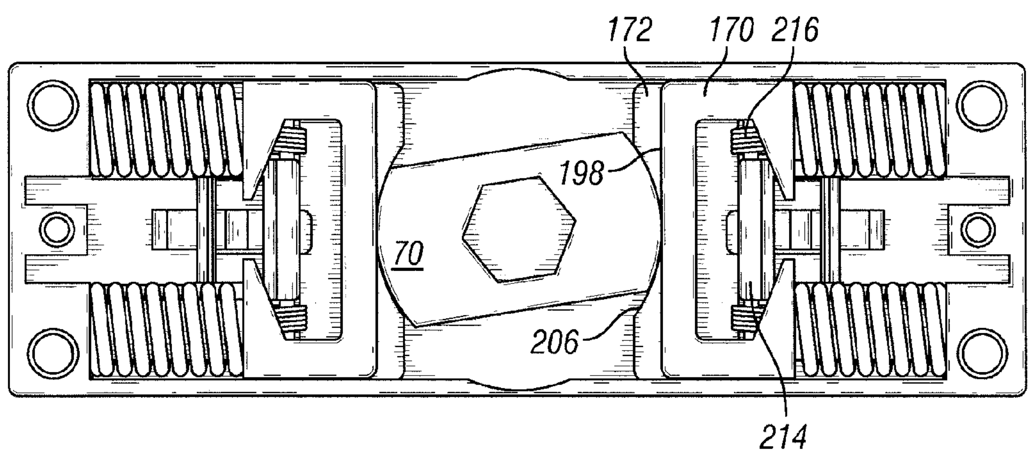

FIG. 25

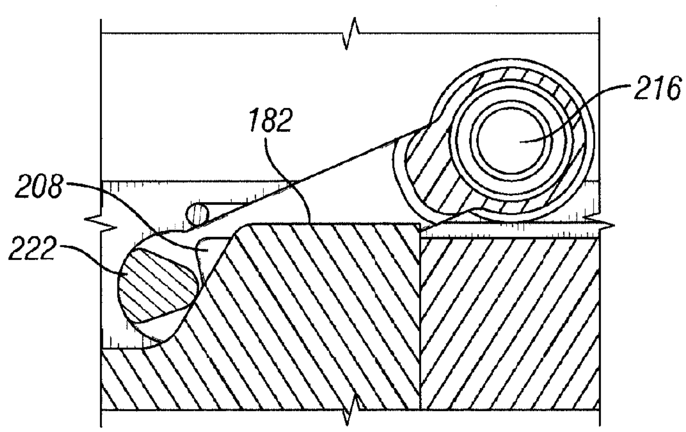

FIG. 26

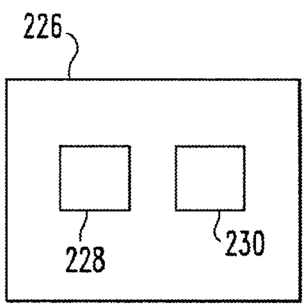

Fig. 27

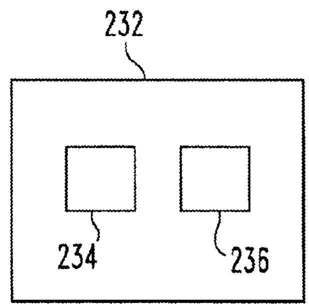

Fig. 28

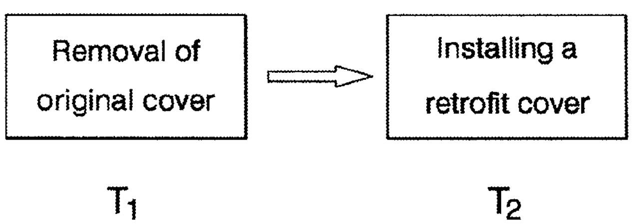

Fig. 29

DOOR ACTUATOR

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 13/243,657 filed Sep. 23, 2011, which claims the benefit of U.S. Provisional Application No. 61/445,419 filed Feb. 22, 2011. The disclosures of each of these applications are incorporated herein by reference.

TECHNICAL FIELD

The present invention generally relates to door and door hardware, and more particularly, but not exclusively, to door closer hardware. In one form the present invention relates to a system and method for boosting the closure force of an automatic door closer. More particularly in one form, but not exclusively, the invention relates to a system and method for boosting the closure force at the point of latching without significantly increasing the opening force.

BACKGROUND

Door closers are often attached to doors to assure that the door is closed after use. The American with Disabilities Act ("ADA") includes guidelines that relate to the manual operating force required to activate door hardware and manually open public doors. Specifically, the ADA requires that a manual operating force of 5 lbs or less is required to open interior and exterior doors.

Current mechanical closer design allows for closers to be set to require manual opening forces measuring between 3.75-4.75 lbs, depending on the application, door weight, and external environment. In some cases, this setting does not provide enough force to assure that the door latches in the closed position.

Some existing systems have various shortcomings relative to certain applications. Accordingly, there remains a need for further contributions in this area of technology.

SUMMARY

In one embodiment, the invention provides a door closer including a power boost assembly. The power boost assembly includes at least one energy storage assembly configured to store energy during door opening and uses the stored energy during door closure to assure that the door latches in the closed position. In another alternative and/or additional embodiment, the present invention is a unique modular device capable of being coupled with existing door and door closer installations.

Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a depiction of a door including a door closer;

FIG. **2** is a graph of force versus door opening angle for a typical door closer;

FIG. **2***a* is a schematic illustration of the regions of a door opening process;

FIG. **3** is a graph of force versus door opening angle for a door closer including a power boost assembly;

FIG. **4** is a side view of the door closer of FIG. **1** with a housing removed to show the internal components;

FIG. **5** is a perspective view of a power boost assembly arranged in a door closed position;

FIG. **6** is a perspective view of the power boost assembly of FIG. **5** arranged in a door opened 15 degrees position during opening;

FIG. **7** is a perspective view of the power boost assembly of FIG. **5** arranged in a door opened 90 degrees position;

FIG. **8** is a perspective view of the power boost assembly of FIG. **5** arranged in a door opened 15 degrees position during closing; and

FIG. **9** is a perspective view of the power boost assembly of FIG. **5** arranged in a door closed position.

FIG. **10** is a view of yet another embodiment of a power boost assembly.

FIG. **11***a* is a view of an embodiment of a base.

FIG. **11***b* is a view of an embodiment of a base.

FIG. **12***a* is a view of an embodiment of a center cam.

FIG. **12***b* is a view of an embodiment of a center cam.

FIG. **12***c* is a view of an embodiment of a center cam.

FIG. **13***a* is a view of an embodiment of a boost cam.

FIG. **13***b* is a view of an embodiment of a boost cam.

FIG. **13***c* is a view of an embodiment of a boost cam.

FIG. **14***a* is a view of an embodiment of a slide cam.

FIG. **14***b* is a view of an embodiment of a slide cam.

FIG. **15***a* is a view of an embodiment of a latch.

FIG. **15***b* is a view of an embodiment of a latch.

FIG. **16** is a view of an embodiment of a pin.

FIG. **17** is a view of an embodiment of a spring.

FIG. **18** is a view of an embodiment of latch.

FIG. **19** is a view of an embodiment of a power boost assembly.

FIG. **20** is a view of an embodiment of a power boost assembly at a door position.

FIG. **21** is a view of an embodiment of a power boost assembly at a door position.

FIG. **22** is a view of an embodiment of a power boost assembly at a door position.

FIG. **23** is a view of an embodiment of a power boost assembly at a door position.

FIG. **24** is a view of an embodiment of a power boost assembly at a door position.

FIG. **25** is a view of an embodiment of a power boost assembly at a door position.

FIG. **26** is a view of an embodiment of a power boost assembly.

FIG. **27** depicts a diagram with modules.

FIG. **28** illustrates a diagram with modules.

FIG. **29** illustrates a retrofit operation.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates.

FIG. **1** illustrates a door **10** including a type of door closer **15**. The closer **15** in the illustrated embodiment includes a rack and pinion mechanical closer design that can be adjustable to allow the opening force to be adjusted, such as, for example, to meet the ADA requirements. The closer **15** can take other door actuation forms and may or may not be adjustable. In some forms of the closer **15**, including those forms that are adjustable, the closer **15** may not provide enough closing force to assure that the door **10** latches in the closed position. For example, when the door closer **15** is configured and/or adjusted to meet an opening force requirement, such as the 5 lb maximum opening force requirement, insufficient return force may be produced by the closer **15** to properly close the door. The present application discloses various embodiments of a power boost assembly that can be used to provide a power boost to a door such as, for example, to supplement a closing force to the door.

FIGS. **2**-**3** provide illustrations of various characteristics of a door and door/door closer combinations. FIG. **2***a*, for example, illustrates one example of the swinging direction of a door and zones through which a door passes as it is open and closed. Though the illustration in FIG. **2***a* depicts a door swing over 90 degrees, some doors can have a larger or smaller swing and can have similar zones that may or may not occur over similar swing angles. FIG. **2** provides an illustration of a force versus door position curve for door opening **20** and door closing **25**. As can be seen, the door closing force parallels the door opening force but is slightly reduced. Thus, less than 5 lbs of force is available during the last 5 degrees of door rotation when latching occurs. Under some conditions, the lower force available may not be sufficient to assure complete closing, such as a failure to provide a latching of the door. FIG. **3** illustrates a curve in which a device of the present application might provide that the force required to open the door **30** is increased slightly and that energy is harvested (or stored) to provide an increased force during closure **35** of the door **10**. As can be seen, the closure force **35** from 5 degrees open to the closed position is actually higher than the force required to open the door **30** through that same range. Other curves having a variety of other characteristics are also contemplated herein.

FIG. **4** illustrates an example of a door closer **15** of FIG. **1** showing the components internal to a housing **50**. The closer **15** of the illustrated embodiment includes a rack and pinion **40** arrangement that is connected to the door **10** via a linkage **45**. The door closer **15** also includes, though not shown, a spring and damper arrangement. The spring can be used to store energy during a door opening motion of the door and return the energy during a closing motion. Various types and arrangements of springs are contemplated for the door closer **15**. The damper can be a fluid type damper used to regulate the speed of door closure. Various types of dampers can be used.

Though the internal view of the door closer **15** does not shown an internal view of the rack and pinion arrangement, it will be appreciated that the pinion **40** rotates about an axis **42** as the door (not shown) is moved relative to the linkage **45**. In some forms the linkage **45** is referred to as an arm and can take a variety of arrangements such as, but not limited to, a scissor arrangement. During opening, the linkage **45** rotates the pinion **40** about the axis **42** which drives the rack, or one or more cams in yet further embodiments of the closer, to compress a spring (also not shown). During closing, the energy stored in the spring moves the rack or the cams which in turn rotate the pinion **40**. The rotation of the pinion **40** moves the linkage **45** and forces the door **10** toward the closed position.

The housing **50** covers the mechanical components of the illustrated embodiment which can be useful in some installations to conceal the door closer **15** during operation. In some embodiments the housing **50** need not be used or can be removed entirely if desired. The housing **50** can take the form of a unitary body that can be affixed to the door, but in can also take on other forms. For example, the housing **50** can be affixed, integrated, part of, etc. to the door closer **15** to set forth just one non-limiting alternative.

The door closer **15** of the illustrated embodiment is in form of a non-handed door closer which can be used for a variety of door and door closer configurations such as right and left handed doors. Embodiments of the present application described further below can be used with non-handed door closers but can also be used with single handed door closers. The non-handed door closer **15** includes a pinion **40** that protrudes from both a top and bottom of the door closer **15** such that it can be coupled with the linkage **45** regardless of its orientation as a right handed or left handed door closer.

In the arrangement of FIG. **4**, a small space **55** is available beneath the pinion **40** and, when the housing **50** is used, within the housing **50**. Though not necessary for the implementation of various embodiments of a power boost assembly (described further below) of the present application, some embodiments are designed to fit within the space **55**. The space **55** can be used such that various embodiments of the power boost assembly described herein can be coupled with existing closers **15** without the need to replace the housing **50** or any other significant components. In some forms, the housing of the closer **15** can include a pocket into which the power boost assembly can be located. In these embodiments the power boost assembly can form a continuous bottom surface with the closer **15**, but in some forms may be discontinuous. Of course, the design could be varied in a manner that would require a different housing **50** or a different component arrangement. In some forms the power boost assembly can be coupled to a pinion that is also coupled to the linkage **45**, regardless of whether the door closer **15** is a non-handed closer. In short, the power boost assembly of the instant application can be attached at a variety of locations, in a variety of orientations, to a variety of objects such as the pinion.

FIG. **5** illustrates one embodiment of a power boost assembly **60** of the present application that can be used with the door closer **15**, and that in some forms is sized to fit within the space **55** illustrated in FIG. **4**. The power boost assembly **60** can be used to store an energy along a portion of a movement of the door and then release the energy along another portion of a movement of the door. For example, the power boost assembly **60** can be used to store an energy when a door is opened and then release the energy when the door is closed, such as in some embodiments when the door is in a latch zone. The energy stored can occur over a first range of a movement of the door and then released over a second range. In the embodiment depicted in FIG. **5** the first range can be the same as the second range, but in other embodiments the energy storage range can be different than the energy release range.

The power boost assembly **60** of the embodiment depicted in FIG. **5** includes a base **65**, a center cam **70**, and two energy storage assemblies **75**. The center cam **70** in the illustrated embodiment is substantially planar and includes an outer perimeter that includes two circular portions **80** and two linear portions **85**. The circular portions **80** can be a constant radius in some forms. A central aperture **90** is formed in the cam **70** and is sized and shaped to engage the pinion **40** such that rotation of the pinion **40** produces a corresponding rotation of the center cam **70**. As will be understood by one of ordinary skill in the art, other perimeter shapes are possible and could be used to arrive at different closing force curves.

Each of the energy storage assemblies **75** includes a closing cam **95**, a spring **100**, and an adjustment member **105**. The closing cam **95** includes a head portion **110** that includes a cam receiving surface **115** and two arms **120**. The cam receiving surface **115** includes a concave circular perimeter sized to receive one of the circular portions **80** of the center cam **70**. The arms **120** are disposed on opposite sides of the closing cam **95** and define two opposite parallel guide surfaces **125** that operate to guide the motion of the closing cam **95** along a reciprocation axis **130**.

A guide portion **135** extends from the head portion **110** along the reciprocation axis **130** and defines a spring chamber **140**. The spring **100** is positioned within the spring chamber **140** and operates to bias the closing cam **95** toward the center cam **70** along the reciprocation axis **130**. Though the spring **100** is shown as a helical coil spring, other types of devices can also be used whether of the spring type or otherwise. The adjustment member **105** engages one end of the spring **100** and is movable along the reciprocation axis **130** to adjust the biasing force produced by the spring **100**. In the illustrated construction, the adjustment member **105** includes a screw that can be rotated to adjust the size of the space in which the spring **100** is disposed, with a reduction in space producing an increased biasing and closure force. Other configurations for the adjustment member **105** can also be used.

The base **65** includes a substantially rectangular plate portion having a recessed region **145** sized to retain and receive the center cam **70**, and a portion of the energy storage assemblies **75**. The guide surfaces **125** of the closing cams **95** engage parallel side surfaces **150** of the base **65** to guide the reciprocation of the closing cams **95**. In addition, two pairs of guide rails **155** are formed in the base **65** with each pair **155** positioned to receive the guide portion **135** of the respective closing cam **95** to further guide the closing cam **95**.

The base **65** of the illustrated embodiment attaches to the existing door closer **15** and fits within the available space **55** to provide a power boost during door closure. In the illustrated construction, threaded fasteners attach the base **65** to the door closer **15** with other attachment arrangements being possible. The threaded fasteners can take the form of screws and bolts. Other arrangements include snaps, straps, and rivets, to set forth just a few examples.

With reference to FIGS. **5**-**9**, the operation of the power boost assembly **60** will now be described. FIG. **5** illustrates the power boost assembly **60** when the door **10** is in the closed position. In this position, the closing cams **95** rest on the linear portions **85** of the center cam **70** and the springs **100** are in their most relaxed position.

As the door **10** rotates, it passes through 15 degrees of rotation as illustrated in FIG. **6**. During this rotation of the door **10**, the center cam **70** displaces both closing cams **95** axially away from the center cam **70** until the circular portions **80** of the center cam **70** engage the cam receiving surface **115** of the closing cams **95**. The displacement of the closing cams **95** compresses the springs **100** and stores energy within the springs **100**. Though the illustrated embodiment is depicted as compressing the springs **100** through the first 15 degrees of rotation, other embodiments of the power boost assembly **60** can be configured to compress the springs **100** through a variety of other rotations.

Further rotation of the door **10** past the 15 degrees of rotation to 90 degrees (FIG. **7**) and beyond does not further compress the springs **100** as the circular portions **80** of the center cam **70** ride within the cam receiving surfaces **115** of the closing cams **95**. Thus, very little additional force is required to open the door **10** when the power boost assembly **60** is attached to the door closer **15**.

During door closure, the center cam **70** rotates in the opposite direction until the door **10** reaches 15 degrees open as illustrated in FIG. **8**. The power boost assembly **60** does not add any closure force to the door **10** until the door **10** reaches the position illustrated in FIG. **8**. As the door **10** moves from the position of FIG. **8** to the closed position illustrated in FIG. **9**, the center cam **70** rotates to a position at which the circular portions **80** no longer engage the closing cams **95** and the linear portions **85** begin to engage the center cam **70**. The springs **100** force the closing cams **95** toward the center cam **70** during this rotation and apply a force **160** to the center cam **70**. The force **160** produces a torque in the close direction which increases the closure force as the door **10** rotates between 15 degrees and 0 degrees (closed).

The present application provides a modular product **60** in all of its embodiments described above and below that can be attached to the pinion **40** on a standard rack and pinion closer **15** that mechanically stores energy during the opening/closing cycle of a door closure and uses that energy to provide a mechanical assistance ("power boost") during the latch portion of a closure. It will have already been appreciated that the power boost assembly can be used and/or configured to be used in any variety of door closer designs whether of the standard rack and pinion closer designs. Whichever the type of door actuation, the power boost assembly **60** of the present application can result in a more efficient and level power curve that best utilizes the forces within a door closer **15**. In some forms the power boost assembly **60** can be integrated with or within the door closer to be sold as a unit, whether easily separated or not, or as a package that can be assembled with the door closer to be used in a door installation.

The power boost assembly **60** illustrated herein, as well as the illustrated door closer **15** is entirely mechanical. However, the internal component design could be executed in multiple ways. The illustrated construction utilizes a balanced cam style symmetrical design, but gears and asymmetrical designs could also be utilized to generate an additional added force once the closer **15** is near the latch position.

Designing an asymmetrical cam type component could potentially allow the energy and force to be harnessed along the opening of the closer **15** over a level power curve and redistribute that energy upon closing at a different point over the power curve. This would allow the user to retract the spring without exerting as much force as would be required to close.

The illustrated design includes a uniform cam **70** that spins in both directions with rotation of the pinion **40**. A clutch style design would allow the pinion **40** to move freely during opening of the door **10**, thereby requiring no additional opening force, but as the closer **15** begins to close, a one direction clutch would wind the spring/assistance and then apply that collected energy once it reaches the latch position of the door **10**.

In another arrangement, the interior design collects and stores energy using an entirely different mechanical design. Utilizing gears and adjusting the gear ratio could potentially perform the same intended result but in a different mechanical design.

Another embodiment of a power boost assembly **60** is shown in FIGS. **10**-**26**. Turning first to FIG. **10**, a view depicting components of the power boost assembly **60** shows a base **65**, center cam **70**, energy storage assemblies **75**, as well as a boost cam **170** and slide cam **172** that movingly interact upon rotation of the center cam **70**. A force can be received by the energy storage assemblies **75** through the boost cam **170** over a motion of the center cam **70** and delivered from the energy storage assemblies **75** through the slide cam **172** over a subsequent motion of the center cam **70**. As will be described below, the boost cam **170** and slide cam **172** are independently movable over a motion of the center cam **70** and are coupled to move together thereafter. In the illustrated embodiment the boost cam **170** and slide cam **172** are coupled to be moved together over a different range of motion of the center cam **70** than the range of motion associated with their independent movement. The range of motion can be, but is not limited to being determined on the basis of different directions of door swing.

A cover **174** is also used in the illustrated embodiment which includes an aperture **176** through which a device such as, but not limited to, the pinion **40** can be cooperatively engaged with the center cam **70**. In one embodiment the cover **174** can be produced from a stamping operation and in the illustrated embodiment includes a number of apertures through which one or more fasteners can pass to couple the cover **174** to the base **65**. The cover **174** can be fastened using a variety of techniques such as a threaded fastener, rivet, snap, straps, etc. Any variety of other forms of attachment are contemplated to couple the cover **174** to the base **65**. The apertures through which fasteners can be used to couple the cover **174** to the base **65** can also be the same apertures used to couple the power boost assembly **60** to the door closer **15**, but it will be appreciated that different apertures can perform the different tasks. The cover **174** can also include an aperture through which the pinion **40** or other device can be passed to couple to the center cam **70**, as shown by the central aperture formed in the cover **174** of the illustrated embodiment. The cover **174** can also include flanges **178** that can be used to align the cover **174** to the base **65** prior to fastening. In addition, though the cover **174** is depicted as a substantially planar device, the cover **174** can be any configuration suitable to enclose various components of the power boost assembly **60**.

With continuing reference to FIG. **10**, FIGS. **11***a* and **11***b* depict views of the base **65** showing additional details. The base **65** is shown as including various sides within which can be found the various components of the power boost assembly **60**, but in some forms the various sides can be incorporated into the cover **174**. In some embodiments the base **65** can be substantially planar and the cover **174** can have various sides. Any various portion(s) of the base **65** and/or cover **174** can be used to couple to the door closer **15** and/or the door. In the illustrated embodiment, the base **65** also includes an aperture through which the pinion **40** or other device can be passed to couple to the center cam **70**. Thus, in some embodiments the power boost assembly **60** can be integrated with a door closer or other suitable device through either the base **65** or the cover **174**. In some forms the power boost assembly **60** need not be fully enclosed by virtue of the cover **174**, base **65**, or the combination thereof. The various components described herein can be integrated wholly with the base **65** or cover **174**, and in some embodiments certain component(s) can be integrated with the base **65** while other(s) are integrated with the cover **174**. Thus, in some embodiments the base **65** and cover **174** can serve as an integrated enclosure, whether completely enclosed or not, for retaining the various components of the power boost assembly **60**. The base **65** can include formations **180** in its sides to permit rotation of the center cam **70**. The base **65** can also include a trigger **182** that can be used to decouple the boost cam **170** and slide cam **172** discussed further below. One or more surfaces, protrusions, or other structure formed in or attached to the base **65** can be used to slidingly receive the slide cam **172** and/or boost cam **170**. Furthermore, the base can also include provisions to provide a mechanical stop to movement of either or both the boost cam **170** and/or slide cam **172**.

FIGS. **12***a*, **12***b*, and **12***c* illustrate various views of an embodiment of the center cam **70** which is used to communicate power between components of the power boost assembly **60** and the door **10** and/or door closer **15**. The center cam **70** in the illustrated embodiment is rotated about an axis and includes surfaces that are configured to interact with both the boost cam **170** and the slide cam **172** through respective interferences. The center cam **70** can be rotated by interaction with a pinion of the door closer **15**, but other configurations, techniques, etc. are contemplated to impart a motion to the center cam **70** by virtue of movement of either or both the door closer **15** and the door **10**. The center cam **70** in the illustrated embodiment includes an opening **184** through which a pinion can be received, but other embodiments may include a protrusion that is receive by a pinion or intermediate structure, among a variety of other approaches.

In the illustrated embodiment the center cam **70** includes a boost cam engagement member **186** and a slide cam engagement member **188**, each of which interact with corresponding cam follower surfaces on the boost cam **170** and slide cam **172**, respectively. The boost cam engagement member **186** and the slide cam engagement member **188** are each shown as taking the form of a protrusion that extends from a body **190** of the center cam **70**. Each of the members **186** and **188** include curved portions **192** and **194** which can take a variety of forms and in the illustrated embodiment are constant radius surfaces, but a variety of other surface configurations can be used. The constant radius, however, need not be measured from a constant origin. For example, the curved portion **192** can include a constant radius as measured from an origin offset from an origin of a constant radius surface of portion **194**. The circumferential reach of each of the members **186** and **188** around the periphery of the center cam **70** can vary between various embodiments. In short, the protrusions can take a variety of shapes, orientations, geometries, etc. A side **196** is oriented to movingly engage the boost cam **170** and slide cam **172** until such position that the members **186** and **188** are rotated into contact with the center cam **70**. The curved portions **192** and **194** thereafter engage either or both the boost cam **170** and slide cam **172**. In some embodiments having a constant radius curved portions, the engagement of the portions and the cams **170** and **172** may lead to little to no movement of the cams relative to the axis of rotation of the center cam **70** and in response to movement of the center cam **70** owing to the constant radius surface. However, the cams **170** and **172** will move in the illustrated embodiment when the side **196** is rotatingly in contact with the cams, more of which will be discussed below.

Turning now to FIGS. **13***a*, **13***b*, and **13***c*, the boost cam **170** of the illustrated embodiment is in the shape of a "C" and includes a boost surface **198** that is used to interact with the boost cam engagement member **186** of the center cam **70**. Other shapes of the boost cam **170** are also contemplated herein. The interaction between the side **196** and boost cam engagement member **186** with the boost surface **198** of the illustrated embodiment determines the motion of the boost cam **170** in the presence of rotation of the center cam **70**. For example, when a corner of the protrusion **186** engages the boost surface **198**, movement of the boost cam **170** relative to the rotation axis of the center cam **70** can be accomplished. When, however, the curved portion **192** engages the boost surface **198**, relatively little movement may occur when compared to engagement with a corner of the protrusion **186**. In some forms no relative movement may occur if, for example, the curved portion **192** is a constant radius surface relative to a center of rotation of the center cam **70**. The boost surface **198** is depicted as planar in the illustrated embodiment, but can take a variety of different shapes in other embodiments.

The boost cam **170** also includes posts **200** and **202** that extend from the boost cam **170** used to provide a surface over which springs **100** can be guided. The posts **200** and **202** can be integral with the boost cam or coupled thereto. The posts **200** and **202** are shown as circular in shape in the illustrated embodiment but can take different shapes in other embodiments. Though the illustrated embodiment is shown as including two posts **200** and **202**, other embodiments can include any of a number of posts. Additionally and/or alternatively, devices other than the posts **200** and **202** can be used to guide the springs **100**. Regarding the springs **100** as well as other components of the power boost assembly **60**, variations in one embodiment described herein are equally applicable to other embodiments unless stated to the contrary. Thus, and as above, though the spring **100** is shown as a helical coil spring, other types of devices can also be used whether of the spring type or otherwise. To set forth just one non-limiting embodiment, an elastomeric material could be used to store energy.

As mentioned above, the boost cam **170** can be coupled to the slide cam **172** over a range of motion of the center cam **70**. In the illustrated embodiment the boost cam **170** includes a mechanism that permits the boost cam **170** to be movingly coupled with the slide cam **172**. In the embodiments described below the boost cam **170** is coupled with the slide cam **172** via a spring loaded latch that is biased in a direction to engage a catch that moves with the slide cam **172**. One form of the spring loaded latch can be seen in FIG. **10**. In one form the spring loaded latch is rotatable about an axis and pivots about a pin. The pin is formed to ride within the formation **204** and will be shown below in more detail.

FIGS. **14***a* and **14***b* depict one form of the slide cam **172** which includes a slide cam surface **206** that is used to interact with the side **196** and slide cam engagement member **188** of the center cam **70**, the interaction of which determines the motion of the slide cam **172** when the center cam **70** is rotated. For example, when the side **196** engages the slide cam surface **206** movement of the slide cam **172** relative to the rotation axis of the center cam **70** is accomplished. When, however, the center cam **70** is further rotated and the curved portion **194** engages the slide cam surface **206**, little to no movement of the slide cam **172** may occur relative to the axis of rotation depending on the relative shape of the interference between the slide cam surface **206** and the curved portion **194**. The slide cam surface **206** is in the form of an arc in the illustrated embodiment but can take other forms in different embodiments.

The slide cam **172** can include a catch **208** to receive a latch coupled with the boost cam **170**. The catch **208** can take a variety of forms and in the illustrated embodiment is in the form of a wall forming an acute angle with surface **210** of the slide cam **172**.

FIGS. **15***a*, **15***b*, **16**, and **17** illustrate components used to form the latch **212** that can be used to couple the boost cam **170** to the slide cam **172**. The latch **212** includes a movable member **214**, a pin **216** upon which the movable member **214** can pivot, and a spring **218**. The movable member **214** includes an aperture **220** through which the pin **216** can be received and includes a shape that permits the pin **216** to be received in the formation **204** of the boost cam **170**. The movable member **214** also includes an engagement portion **222** used to interact with the catch **208**. The spring in the illustrated embodiment also includes an aperture **224** through which the pin **216** can be received. FIG. **18** illustrates an integrated assembly of the latch **212** that is depicted apart from the boost cam **170**.

FIG. **19** depicts a schematic of one embodiment in which the boost cam **170** can be coupled to the slide cam **172** through the use of the latch **212** and catch **208** such that both are encouraged to move together during some portion of operation of the power boost assembly **60**. The latch **212** is pivotingly connected to the boost cam **170** and is structured to engage a portion of the slide cam **172**. The latch **212** can be biased using the spring **218** in a direction to encourage engagement with the catch **208** when the boost cam **170** reaches a position relative to the slide cam **172** that permits engagement. In some forms the latch **212** can ride on a surface **210** as the boost cam **170** moves toward the catch **208** whereupon the latch **212** engages the catch **208** at a relative position between the two. The latch **212** and catch **208** can each take a variety of forms some of which have been described herein. Any number of catches and latches can be used in the power boost assembly **60**. Though the latch **212** and catch **208** are associated with each of the boost cam **170** and slide cam **172**, respectively, it will be understood that many different configurations of the catch and latch are contemplated. Furthermore, other types of devices can also be used to couple the boost cam **170** and slide cam **172** as a function of door position.

A trigger **182** with the base **65** can be used to de-latch the latch **212** such that the boost cam **170** and slide cam **172** are free to move independent from one another. The trigger **182** is shown as being fixed relative to the base **65** and is used to urge the latch **212** to decouple from the catch **208**. Various arrangements of the latch **212** and trigger **182** are contemplated herein other than the illustrated embodiment. To set forth just one non-limiting example, the latch **212** can be coupled to the slide cam **172** in some forms and structured to engage the boost cam **170**. Further description of the latch **212** and trigger **182** will be described further below.

To describe operation of the power boost assembly **60**, one non-limiting embodiment will be illustrated in FIGS. **20-25**, each figure representing a different door opening and pinion rotation. Turning first to FIG. **20**, the embodiment depicts the power boost assembly **60** at a door closed position. For ease of description the power boost assembly **60** will be assumed to be attached to a non-handed closer on the free pinion via a bolt that draws the power boost assembly **60** toward the door closer **15**. FIG. **21** represents an initial movement of the door to a 4 degree opening position and the pinion is at 12 degrees of rotation. When the door **10** rotates, which causes motion of the linkage **45** discussed above, the pinion **40** likewise rotates causing the center cam **70** to rotate in turn. When the center cam **70** rotates the slide cam engagement member **188** engages the slide cam **172** causing it to move toward an end of the base **65**. In one form the movement of the slide cam **172** caused by interaction with the slide cam engagement member **188** can occur over the first 8-10 degrees of door movement at which time the slide cam surface **206** receives curved portion **194** of the center cam **70** thus halting further movement of the slide cam **172** caused by the center cam **70**. In the illustrated embodiment the first 8-10 degrees of movement are in the door opening direction, but other embodiments need not be limited to this direction as such. FIG. **22** depicts the door at a 7 degree opening position that corresponds to a pinion rotation of 19 degrees.

At about the same position that the slide cam **172** engages the curved portion **194** of the center cam **70**, the outer portion of the center cam **70** that includes the curved portion **192** engages the boost cam **170** and causing it to move relative to the axis of rotation of the center cam **70**. FIG. **23** illustrates such an arrangement where the door is in a 25 degree opening position and the pinion is at about 47 degrees of rotation. At this configuration the energy storage assembly **75** is being used to store energy as a result of the boost cam **170** movement. In one form the boost cam **170** can be moved relative to the axis of rotation of the center cam **70** until about 60 degrees of door movement in one embodiment at which point the boost surface **198** engages the curved surface **192** of the center cam **70** thus halting further build up of energy in the energy storage assembly **75**. At or about the same time that the boost cam **170** no longer builds an energy in the energy storage assembly **75** the latch **212** engages the catch **208** to couple the boost cam **170** and slide cam **172** to move together. In the illustrated embodiment of FIG. **24**, the door is at 55 degrees of opening position and the pinion is at about 80 degrees of rotation which in the illustrated embodiment corresponds to a position where the latch **212** engages the catch **208**. FIG. **25** illustrates a door opening of 70 degrees and a pinion rotation of about 95.6 degrees.

When the door direction is reversed, the protrusion **186** of the center cam **70** begins to withdraw from the boost cam **170**, but because the boost cam is latched to the slide cam **172**, and because the slide cam **172** remains on the curved surface **194** of the center cam **70** thus preventing relative movement, the boost cam **170** likewise remains in place and the energy in the energy storage assembly **75** remains substantially the same.

When the door approaches the point at which the slide cam **172** engages side **196** from the outer portion **194** of the center cam **70** and subsequent relative motion is permitted, the energy built up in the energy storage device is imparted to the slide cam **172** via the latch **212** and the slide cam **172** therefore urges against the protrusion **188** of the center cam **70** causing a torque and thus power boost to the door. The power built up by the energy storage assembly **75** over a range of motion that caused the boost cam **170** to move is thus released at least in part through the slide cam **172** over the range of motion of the slide cam **172**. In the embodiment described above it can be described as thus: power build up from about 8-10 degrees to 60 degrees during a door opening; power draw down from about 8-10 degrees to zero during a door closing. Various other ranges of power build up and power draw down are contemplated herein.

FIG. **26** illustrates another embodiment of the latch, catch, and trigger portion of the power boost assembly. The shape of the trigger **182**, the catch **208**, and the catch **208** promote decoupling of the boost cam **170** and slide cam **172** when the center cam **70** is rotated to a closed position.

The embodiments of the power boost assembly **60** described above can be coupled with doors and door closers in a variety of manners. In some applications the power boost assembly can be removably affixed to a door and/or door closer to provide a power boost over a range of motion of a door. Any portion of the power boost assembly can be affixed to the door and/or door closer. For example, an outer surface of the base, cover, or both can be used to engage a surface of the door and/or door closer. The outer surface of the base, cover, or both can be coupled to a receiving surface of the door and/or door closer such as but not limited to a corresponding outer surface of the door and/or door closer. In some applications the power boost assembly can be integrated with a door closer such as to form a package. In other embodiments the power boost assembly can be modular and capable of being readily affixed to, and possibly removed from, an existing door and/or door closer with minimal maintenance activity. For example, in some situations a pre-installed door and door closer may have insufficient force to complete a door latching sequence. A power boost assembly can be coupled with the door and/or door closer to provide sufficient power to complete the door latch. Various other forms, combinations, etc are contemplated herein.

One aspect of the present application provides an apparatus comprising a power boost package configured as an attachable module for use with a spring-damper door actuator to move a door including a chassis and having a portion configured to be in power communication with the door actuator for movement of the door, the chassis of the package forming a structure to retain: an actuation member structured to contribute a power in the movement of the door, and an energy storage device capable of being energized by movement of the actuation member, the energy storage device operable to store a boost energy as a result of a first movement of the actuation member, and configured to release the boost energy at a release position of the actuation member, the boost energy released through the actuation member as a result of a second movement of the actuation member.

One feature of the present application provides wherein the attachable module is releasably attachable to the spring-damper door actuator.

Another feature of the present application provides wherein the attachable module can be affixed to the spring-damper door actuator using an elongate threaded shaft, and wherein the attachable module includes an opening to receive a pinion of the spring-damper door actuator.

Still another feature of the present application provides wherein the attachable module is configured for attachment to the spring-damper door actuator on a free end of a pinion of a non-handed door actuator.

Yet still another feature of the present application provides wherein the first movement of the actuation member to store the boost energy occurs over a first range, and wherein the second movement of the actuation member to release the boost energy occurs over a second range different than the first range.

Still yet another feature of the present application further includes a first reaction member and a second reaction member configured to be in contact with the actuation member, the first reaction member configured to energize the energy storage device as a result of the first movement of the actuation member, the second reaction member configured to receive the boost energy from the energy storage device as a result of the second movement of the actuation member.

A further feature of the present application provides wherein the power boost package includes an outer surface to enclose the energy storage device, the first reaction member, and the second reaction member, and wherein the attachable module is releasably attachable to the spring-damper door actuator by contacting the outer surface with an exterior of the spring-damper door actuator.

A still further feature of the present application provides wherein the actuation member includes a first eccentric surface and a second eccentric surface each capable of rotating about an axis, the first reaction member and the second reaction member in the form of cam followers to the first eccentric surface and second eccentric surface.

A yet further feature of the present application provides wherein the actuation member includes a periphery having the second eccentric surface and a constant radius surface such that upon rotation of the actuation member the second reaction member moves when in contact with the second eccentric surface and remains relatively static when in contact with the constant radius surface.

Still yet a further feature of the present application further includes a latch and catch structured to permit independent movement of the first reaction member and second reaction member during the first movement, and couple the first reaction member and second reaction member to have sympathetic movement during the second movement.

Yet still a further feature of the present application provides wherein the power boost package includes a trigger to decouple the first reaction member and the second reaction member from the latch and catch.

Another aspect of the present application provides an apparatus comprising an add-on supplemental door actuation module having an outer housing structured for engagement to a door closer device and having an actuator configured to be in force communication with the door closer device, the add-on supplemental module structured to activate an energy storage device of the actuator to store an energy along a swing of a door when the door closer is actuated in a first direction and structured to maintain the stored energy via a power modulator of the actuator when the door closer is actuated in a second direction until the door reaches a boost location wherein the stored energy is released from the actuator to deliver a boost to a door to supplement the door closer device.

A feature of the present application provides wherein the actuator includes a connecting member coupled to move with a first actuation member and a second actuation member, the connecting member structured to activate the energy storage device by encouraging movement of the first actuation member, the connecting member structured to receive the stored energy released from the energy storage device via the second actuation member.

Another feature of the present application provides wherein the power modulator links the first actuation member and the second actuation member to move together over a range of motion of the connecting member.

Yet another feature of the present application provides wherein the first actuation member and the second actuation member are in the form of cam followers, the connecting member having cam lobes configured to interact with the first actuation member and second actuation member.

Still another feature of the present application provides wherein the first actuation member includes a wider range of motion than the second actuation member.

Yet still another feature of the present application provides wherein a connecting member is configured to receive an energy from a pinion of the door closer device when it is actuated in the first direction and store the energy with the energy storage device, and wherein the connecting member can impart an energy from the energy storage device to the pinion of the door closer device when the door closer is actuated in the second direction.

Still yet another feature of the present application provides wherein the second direction is in a door closing direction and the boost location is in a latch region of the door, and wherein the pinion is a free pinion of a non-handed door closer device.

A further feature of the present application provides wherein the outer housing of the add-on supplemental door actuation module is structured for engagement to an outer portion of the door closer device.

A still further feature of the present application further includes a casing configured to enclose the add-on supplemental door actuation module and the door closer device.

Yet still a further feature of the present application provides wherein the casing and add-on supplemental door actuation module are packaged as a kit for use with a door installation (one embodiment of which is shown in FIG. **27** as a kit **226** that includes an add-on supplemental door actuation module **228** and casing **230**).

Yet another aspect of the present application provides an apparatus comprising a door closer add-on module for use with a door closer having an actuation member for receiving a load and storing it in an energy storage device in a build-up mode, the actuation member configured to distribute load from the energy storage device in a draw down mode, and means for storing the load according to a first profile of movement of the actuation member, means for distributing the load according to a second profile of movement of the actuation member.

A feature of the present application provides wherein the first profile of movement is determined on the load stored in the energy storage device as a function of position of the actuation member.

Still yet another aspect of the present application provides a method comprising retrofitting a door and door closer installation that includes: procuring a door closer add-on device capable of providing a boost power to the door closer over a swing of the door, the door closer add-on device capable of building an energy over a first movement of a swing of a door, storing the energy over a second movement of a swing of a door, and dispensing the energy over a third movement of a swing of a door, coupling the door closer add-on device to be in force communication with the door to contribute a power to the door.

A feature of the present application provides wherein the door closer add-on device is structured to provide the power to the door over a latch region of the door.

Another feature of the present application provides wherein the coupling includes engaging an actuation member of the door closer add-on device.

Still another feature of the present application provides wherein the engaging includes inserting a pinion of the door closer into an actuation receiving portion of the door closer add-on device.

Yet still another feature of the present application provides wherein the door closer is a non-handed closer, and wherein the engaging includes coupling a portion of the door closer add-on device with a free pinion of the non-handed closer.

Still yet another feature of the present application further includes installing a retrofit cover over the coupled door closer and door closer add-on device (one embodiment of which is shown in FIG. **28** illustrating a retrofit cover **232**, a door closer **234**, and door closer add-on device).

A further feature of the present application provides wherein the installing occurs after removal of an original cover used over the door closer (one embodiment of which is shown in FIG. **29** showing the installing occurring at time T_2 subsequent to the removal of an original cover at time T_1).

Still a further feature of the present application provides wherein the building includes energizing an energy storage device by movement of a first cam follower, wherein the storing includes locking a first cam follower to a second cam follower such that an energy state of the energy storage device is preserved, and wherein the dispensing includes following a second cam follower to de-energize the energy storage device.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the inventions are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicate that the feature so described may be more desirable, it nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the invention, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

What is claimed is:

1. A door operator, comprising:

a pinion configured to transmit forces between the door operator and a door, wherein the pinion is biased to urge the door in a closing direction;

a power boost assembly in power communication with the pinion for supplemental power boost movement of the door to supplement the biasing force on the pinion as the door is being closed, the power boost assembly comprising:

an actuation member structured to contribute a power in the movement of the door; and

an energy storage device capable of being energized by movement of the actuation member, the energy storage device operable to store a boost energy as a result of a first movement of the actuation member, and configured to release the boost energy at a release position of the actuation member, wherein the boost energy is released through the actuation member as a result of a second movement of the actuation member.

2. The door operator of claim **1**, wherein the first movement of the actuation member to store the boost energy occurs over a first range, and wherein the second movement of the actuation member to release the boost energy occurs over a second range different than the first range.

3. The door operator of claim **1**, wherein the door operator is configured for use with a swinging door having an open position and a closed position;

wherein a main zone of door movement includes the open position, and a latch zone of door movement is defined adjacent the closed position;

wherein the pinion is configured to rotate in a first direction in response to an opening swing of the door toward the open position, and to rotate in a second direction in response to a closing swing of the door toward the closed position;

wherein the power boost assembly is configured to store the boost energy in the energy storage device in response to rotation of the pinion in the first direction during at least a portion of the opening swing, to retain the stored energy in the energy storage device during the second movement of the door through the main zone, and to discharge the energy from the energy storage device during the second movement of the door through at least a portion of the latch zone;

wherein the power boost module is further configured to urge the pinion in the second direction with the discharged energy, thereby supplementing the biasing force on the pinion.

4. The door operator of claim **3**, wherein the energy is mechanical energy.

5. The door operator of claim **4**, wherein the energy storage device includes a spring.

6. The door operator of claim **1**, wherein the door has an open position and a closed position, wherein a boost location is defined between the open position and the closed position, and the actuation member has the release position with the door at the boost location;

wherein the power boost assembly is structured to drive the actuation member in a first manner in response to a first movement of the door, wherein driving the actuation member in the first manner results in the first movement of the actuation member, and the actuation member is configured to store the boost energy in the energy storage device when driven in the first manner;

wherein the power boost assembly is further structured to release the stored boost energy when the door reaches the boost location, and to drive the actuation member in a second manner with the released boost energy, wherein driving the actuation member in the second manner results in the second movement of the actuation member; and

wherein the actuation member is configured to provide a supplemental actuation when driven in the second manner, the supplemental actuation contributing to a second movement of the door toward the closed position.

7. The door operator of claim **6**, wherein the operator is configured to operate in a first operator direction in response to the first movement of the door, and to operate in a second operator direction in response to the second movement of the door.

8. The door operator of claim **7**, wherein the first movement of the door is in an opening direction toward the open position.

9. The door operator of claim **6**, wherein the pinion is spring-biased and urges the door toward the closed position.

10. The door operator of claim **9**, wherein the supplemental actuation includes a boost force supplementing the spring bias on the pinion.

11. The door operator of claim **6**, wherein the energy is mechanical energy.

12. The door operator of claim **11**, wherein the energy storage device includes a spring operable to store the mechanical energy.

13. A method of operating a door operator during movement of a door, wherein the door operator includes a pinion configured to transmit forces between the door operator and the door, and a power boost assembly engaged with the pinion, the method comprising:

providing, with a spring, a biasing force on the pinion to bias the door in a closing direction;

operating the door operator in a first configuration as the door moves through a first movement, wherein operating the door operator in the first configuration includes:

rotating the pinion in response to the first movement of the door;

driving an actuator of the power boost assembly in a first manner in response to rotation of the pinion; and

storing energy in an energy storage device of the power boost assembly in response to the driving the actuator in the first manner; and

operating the door operator in a second configuration as the door moves through a second movement in the closing direction, the operating the door operator in the second configuration including:

urging the door in the closing direction with the biasing force of the spring on the pinion;

releasing the energy from the energy storage device; and

driving the actuator in a second manner with the released energy to provide a boost force on the pinion;

wherein the boost force supplements the biasing force of the spring on the pinion and further urges the door in the closing direction.

14. The method of claim **13**, wherein the first movement direction is an opening movement of the door.

15. The method of claim **14**, wherein rotating the pinion in response to the first movement of the door includes rotating the pinion in a first rotational direction, and driving the actuator in the second manner includes urging the pinion in a second rotational direction with the boost force.

16. The method of claim **15**, wherein the second movement of the door includes movement through a first zone and subsequent movement through a second zone toward a closed position, and wherein operating the door operator in the second configuration further comprises retaining the energy in the energy storage device during the movement through the first zone and releasing the energy from the energy storage device during the subsequent movement through the second zone.

17. The method of claim **15**, wherein operating the door operator in the first configuration further includes compressing the spring in response to rotation of the pinion in the first rotational direction, and wherein urging the door in the closing direction with the biasing force of the spring includes expanding the spring.

18. The method of claim **17**, wherein a boost location defines a boundary between the first zone and the second zone, the retaining the energy includes retaining the energy until the door reaches the boost location, the releasing the energy includes releasing the energy when the door reached the boost location, and the boost force drives the door through the second zone toward the closed position.

19. The method of claim **18**, wherein the second zone has an angular span between 5° and 15°, inclusive.

20. The method of claim **13**, wherein the energy storage device is a mechanical energy storage device.

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